Sensors for Micro Aerial Vehicles

MAV Workshop, Elmau/Germany

22 Sept 2003

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
23 JUL 2004	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Sensors for Micro Aerial Vehicles	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **US Army RDECOM CERDEC**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM001689, EOARD-CSP-03-5073 Micro Air Vehicle Workshop., The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**25**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Briefing Outline

- Small Unmanned Testbed Aircraft
- Sensors and Technologies for Micro Aerial Vehicles
  - Uncooled Infrared
  - Image Mosaic and Stabilization
  - Mine Detection
  - Mission Equipment Package for Small UAVs
  - Mission Equipment Package for Micro UAVs
  - Acoustic
  - Chemical
  - Communications

Small Unmanned Testbed Aircraft

Night Fox

Pointer

Raven

NVESD's In House Assets

Other Platforms for Sensor Testing

Dragon Eye

iStar

Sensor Limitations of Micro Aerial Vehicles

- **Weight**
- **Size/Volume**
- **Data link**
- **Image/Line-of-Sight Stability**
- **Cost**

Sensors & Technologies for Micro Aerial Vehicles

- Electo-Optic (TV)
- Uncooled Infrared
- Passive Countermine
- Mission Equipment Packages (MEP) for Small and Micro UAVs
- Acoustic
- Chemical

Uncooled IR Technologies for Small and Micro UAVs

160x120 (19.2K Pixels)

0. 5 lb

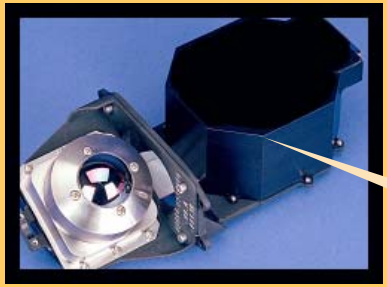
0.25 lb

320x240 (76.8K Pixels)

1.5 lbs

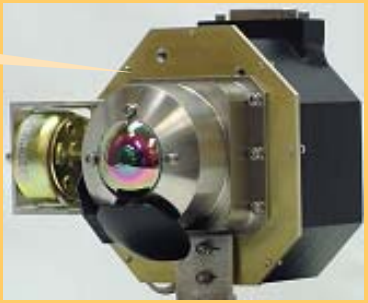
0.75 lb

640x480 (307.2K Pixels)

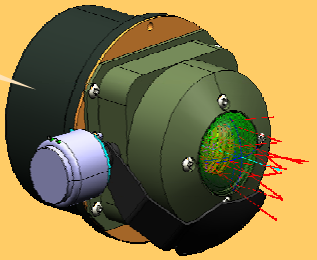


0.7 lb

0.6 lb

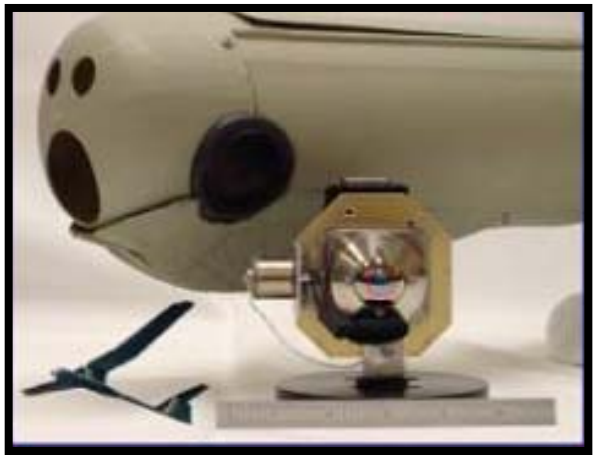


0.4 lb



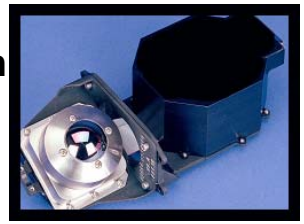
Small UAV Video
640 x 480 UCIR FPA

Pointer

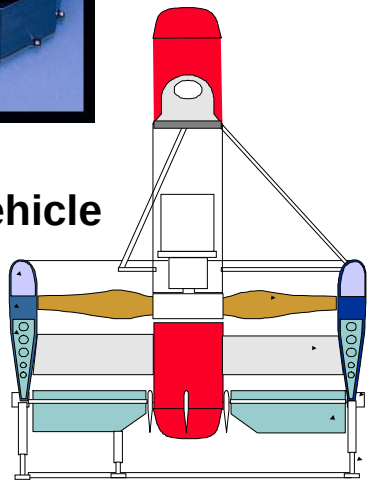


640 x 480 UCIR Imager
Flight on Pointer SUAV

640 x 480 FPA with
Electronics < .75
Pounds



Organic Air Vehicle

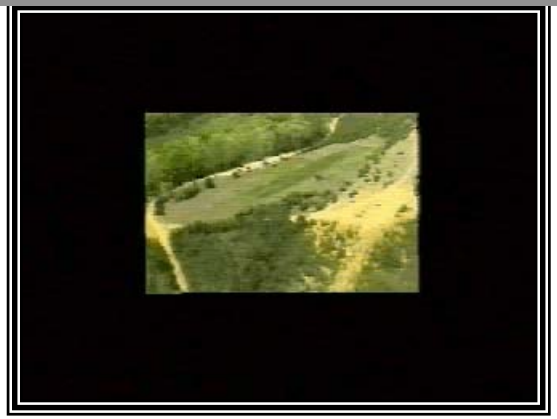


Red areas Represent
Payload Cavities

High Resolution Sensor Capability for Small UAVs

Airborne Video Surveillance (AVS) Image Mosaic and Stabilization

Non- Stabilized Raw UAV Sensor Video



Real-time Mosaic of UAV Sensor Video

Electronically Stabilized Video

Full Resolution Mosaic Image

Provides Wide Area View w/ Full Resolution Chip Capability

Real-Time Mosaicing Provides Electronic Stabilization for SUAVs

Mine Detection
(Reststrahlen Multi-Spectral Camera)

Objective:

- **Find Buried Mines/Minefields on Roads**

Approach:

- **Exploit spectral phenomena of disturbed earth in Longwave-Infrared (LWIR) and Vegetation in Near-Infrared (NIR)**

Tasks

Analysis/Modeling

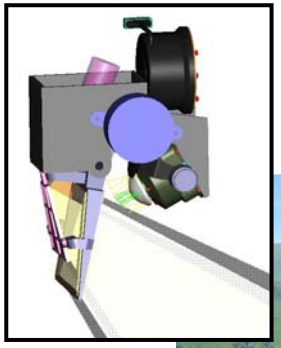
Sensor Design & Devel.

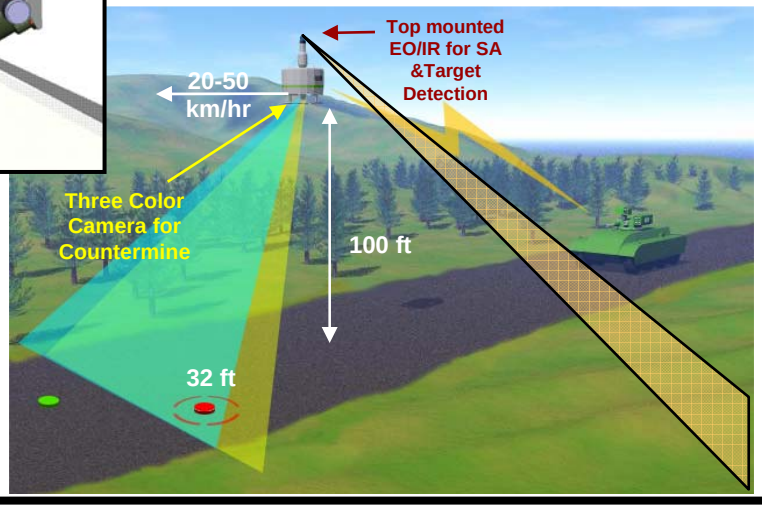
Ground Processor Design & Devel.

Systems Integration

Flight Tests & Demos

Multi-Spectral Sensor for OAV

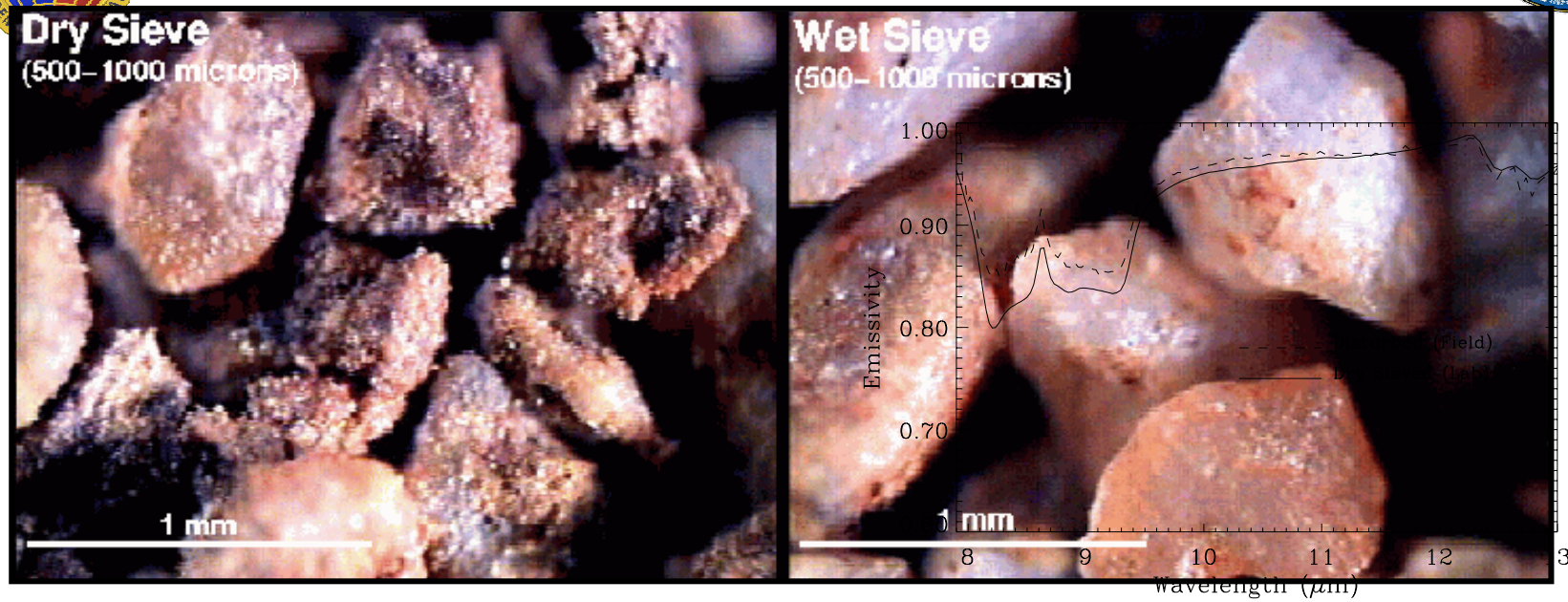


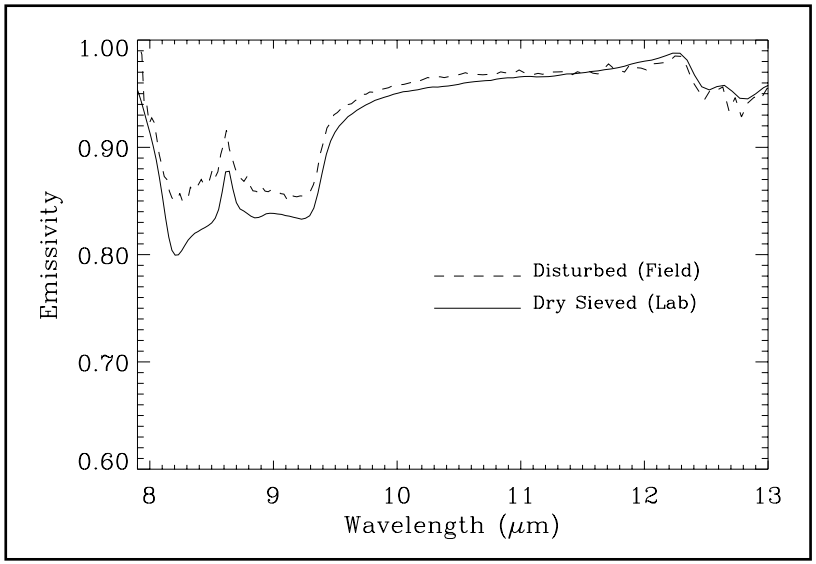


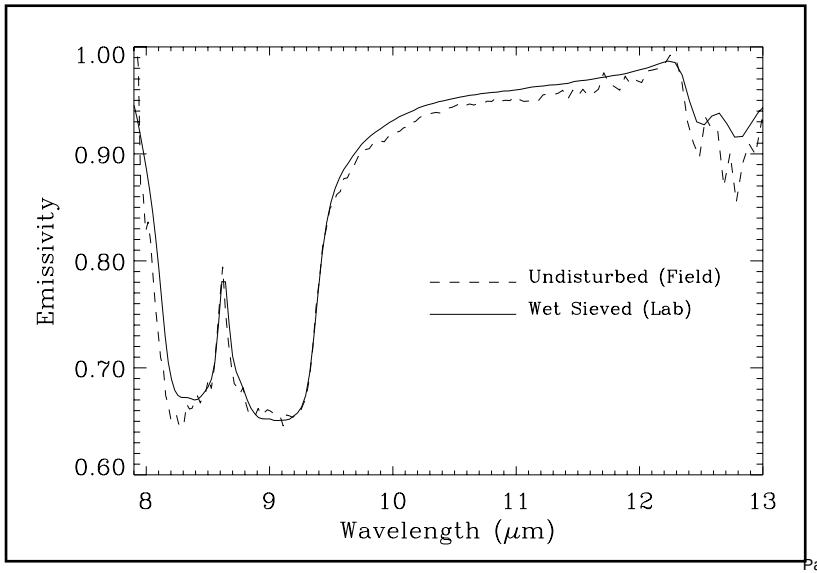
Performance Specifications:

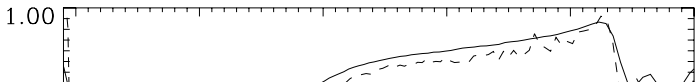
- **Uncooled Infrared Technology**
- **Three Spectral Bands**
  - **0.9 – 1.0 microns (NIR)**
  - **8.4 – 9.4 microns (LWIR in-band)**
  - **10.5 – 12.2 microns (LWIR out-of-band)**
- **19” OAV Compatible**

Mine Detection Physical Mechanism
University of Hawaii

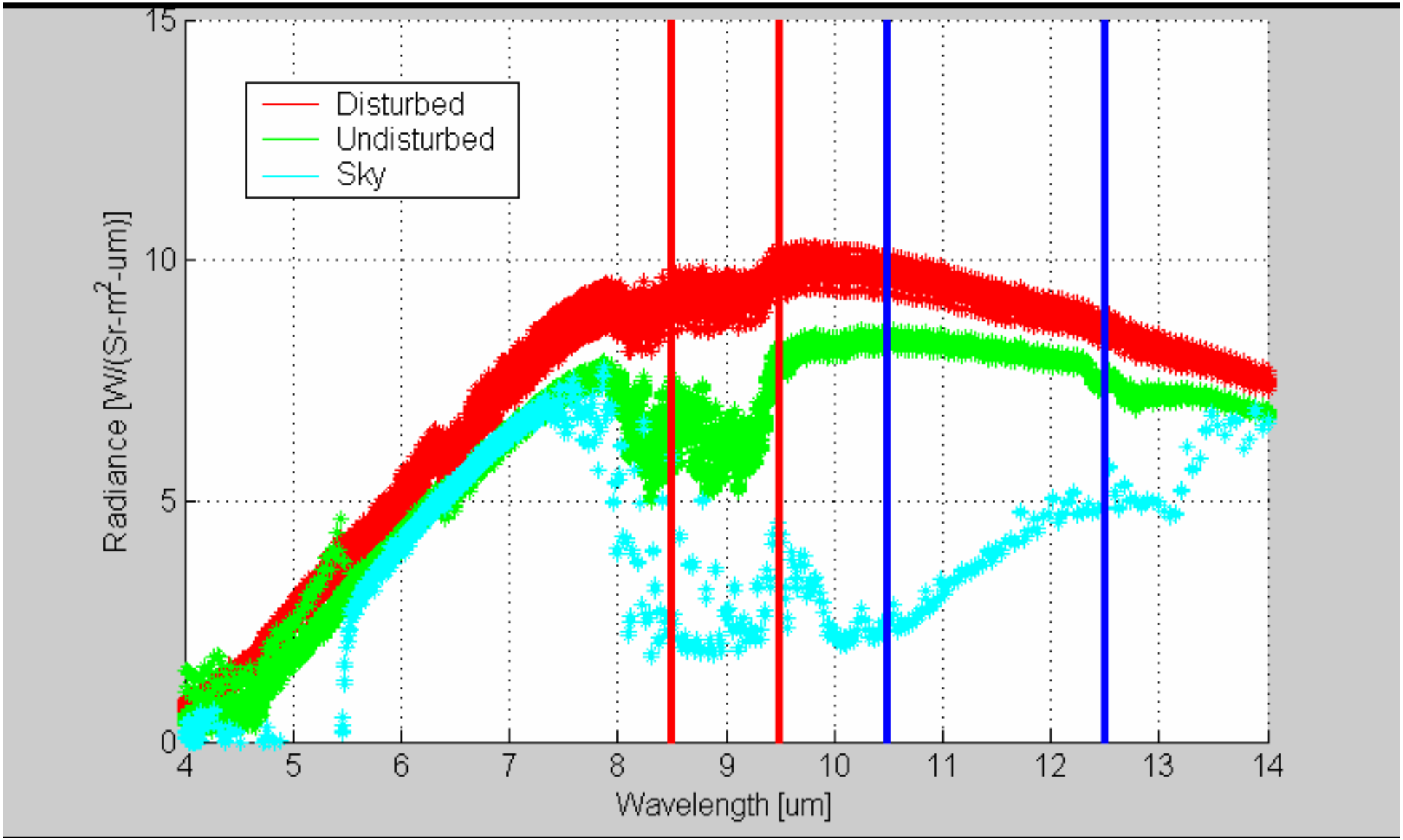








Reststrahlen, Open Field
NVESD/ University of Hawaii



Mission Equipment Package for Small UAV

~10-12 lbs Payload

- **LADAR**
- **Laser Vibrometry**
- **Picture in Picture (PnP)**
- **Laser Rangefinder/Designator (LRF/D) – Lightweight**
- **Collision Avoidance**
  - **Micro-LADAR**
  - **Optical Flow**
  - **Acoustic**
  - **Stereo Vision**
  - **Micro-RADAR**

Mission Equipment Package (MEP) for Small UAV

Objective:

- **Develop, integrate and demonstrate a Mission equipment package consisting of sensor technologies performing a significant portion of the RSTA mission requirements for the Small UAV.**

(Exploring "Picture-in-Picture" concept, "see-through-foliage" sensor, and laser designator)

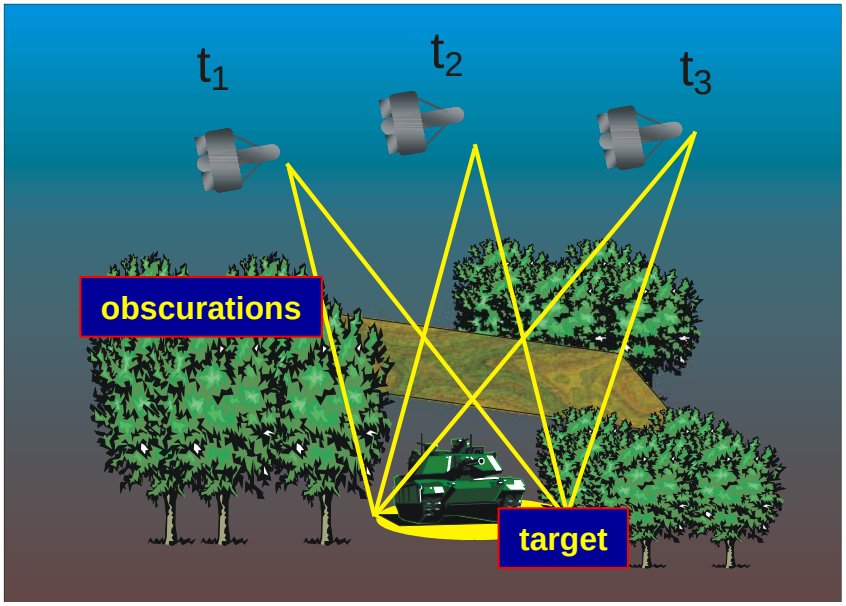
Tasks

Picture-in-Picture
- Rooftop Concept
- Sensor Development
- Test & Demo

Laser Designator
- Design & Development
- Test & Demo

See-Through-Foliage
- BAA
- Sensor Development
- Test & Demo

RSTA Sensors for Small UAV



Performance:

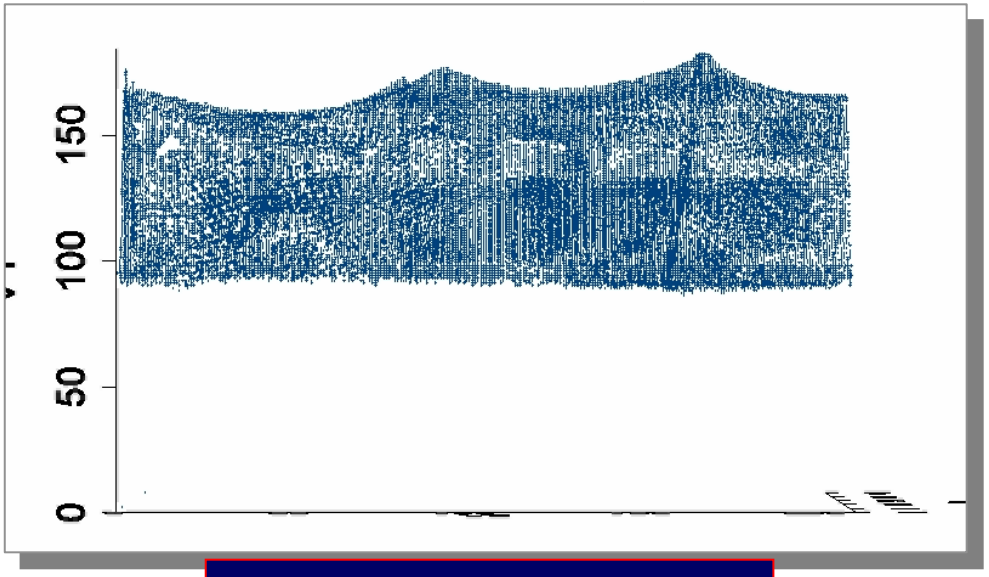
- **Sized for Small UAV (10-12 lbs).**
- **Accurate ID and Targeting**
- **Laser Designation**

MEP for Small UAV
Passive Recce System with "Picture in Picture" (PnP)

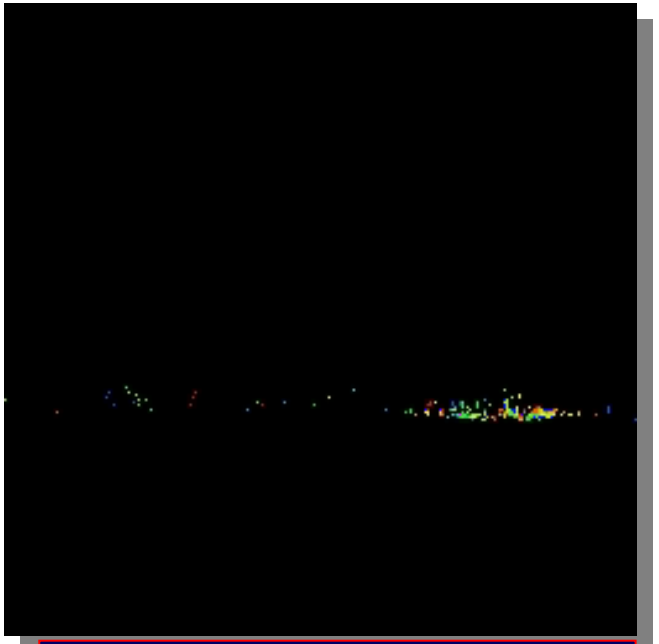
Search-Detect with Wide Angle UCIR
Identify with High Resolution MWIR

MEP for Small UAV LADAR Foliage Penetration

Photograph of Vehicle Behind Camo



Point Cloud Graph



Sliding Range Gate

Target ID in Dense Cover (95% Obscuration)

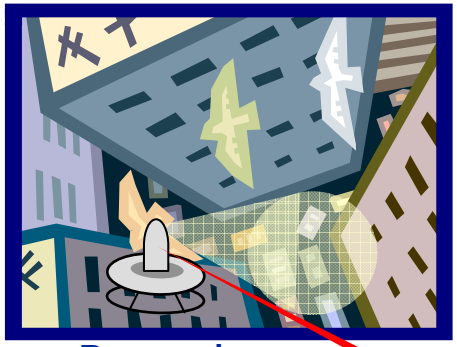
MEP for Micro UAV

Operational Utility

- Terrain Independence – Operations in MOUT and Complex Terrain
- NLOS Observation from Key Terrain – Perch-Stare/Hover (Line of Sight from Location)
- Unmanned Observation of Key Avenues of Approach - Bounding Overwatch
- Rear-Area, Flank, & Perimeter Security with Minimum Manning
- Assured Mobility
- Mine Detection

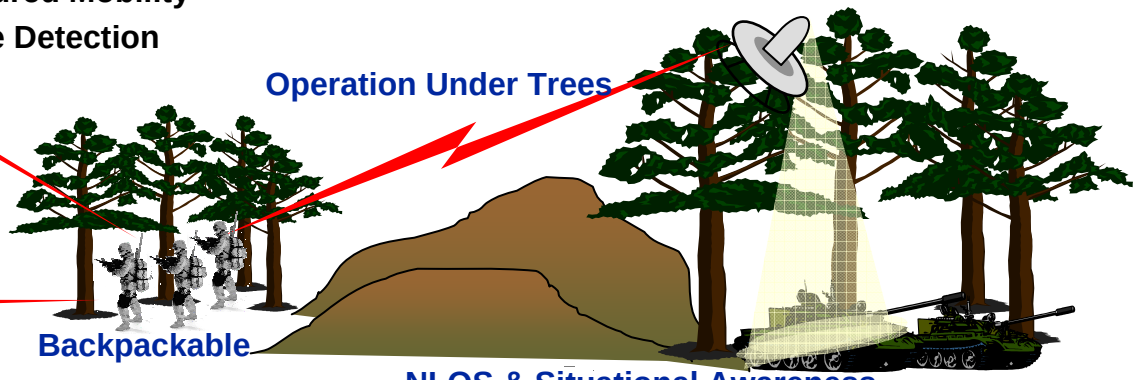
Sensor Technology Options

- Uncooled IR
- E-O Visible CCD
- SWIR w/Illuminator
- Acoustic Detection
- Chemical Detection
- Obstacle/Collision Avoidance
- Real Time Video Mosaics & Registration



Reconnaissance and Surveillance

Re-locatable Unattended Sensors



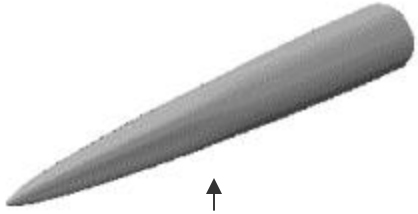
MEP for MAV Provides Small Units with Organic RSTA Capabilities for Situational Awareness and Force Protection

Acoustic Sensor Technology

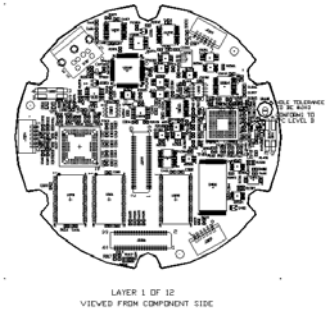
BAT Sensor

Specifications

- 0.375” diameter, 5” length acoustic probes
- 3.9” diameter by 1” thick electronics processing board
- Power requirements - 7.5-16 V DC, 700 milliwatts
- Total system weight - 3.2 ounces w/o dedicated battery
  6.4 ounces w/ dedicated battery
- Texas Instruments TMS320C5410 processor
- EIA standard RS-232 interface
- 1Hz steer-to message update rate
- Outputs include:
  - detection frequency & signal-to-noise ratio
  - target bearing & elevation angles
  - target RPM & classification
  - raw acoustic signals (on extra serial ports)
- Supports triangular sensor array



BAT Acoustic Probe

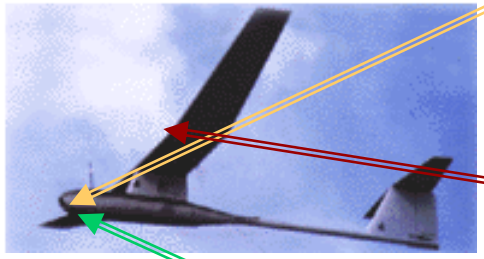


Electronic Processing Board

Finds targets under canopy and in tree lines.

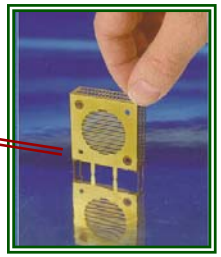
Chemical Detection Technologies for Small UAVs

Small UAV



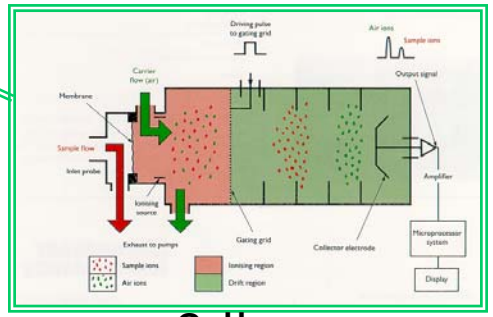
8 → 3 oz.

Long wave IR sensor locates potential cloud



1 oz.

Swatch can be passed through cloud and returned to a specific location for detailed analysis



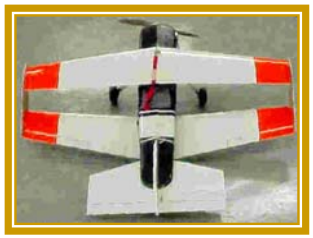
<2 lbs.

Adapt handheld analyzer for non return analysis

Low Cost, Autonomous and Attritable

Small UAV is compact and autonomous
It takes the risk instead of personnel

Communications



• Aircraft transmits video, position and attitude data

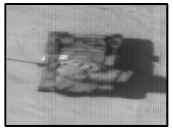
RS-170

RS-170 BNC RG-59

Meta Data RS-232

• Video and data sent to laptop via serial connection

Ethernet/ Wireless



• Ground Station receives data from aircraft

• Laptop has Government owned software for targeting

• Image Capture

Software generates image chip w/ target solution in NITF Image format for transmission to higher echelons

Summary

- MAV Sensor Limitations
  - Weight
  - Size/Volume
  - Data link
  - Image/Line-of-Sight Stability
  - Cost (Must be Attritable)
- Sensors & Technologies
  - Electo-Optic (TV)
  - Uncooled Infrared
  - Passive Countermine
  - Mission Equipment Packages (MEP) for Small and Micro UAVs
  - Acoustic
  - Chemical

Questions?

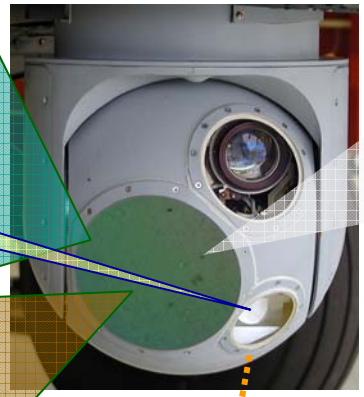
Back-ups

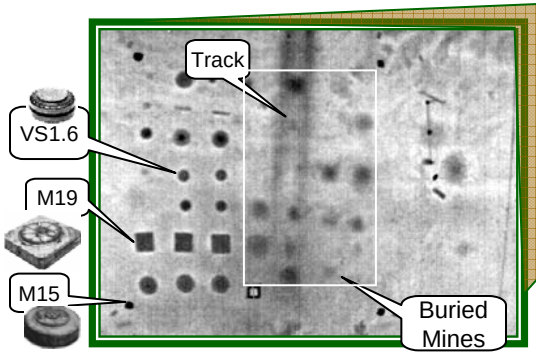
Advanced EO/IR Payload

Long Range,
High Quality,
All Digital Imagery

One Payload
(55 lbs)

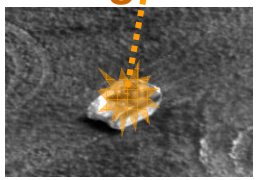
Fast Wide Area Search/Step-Stare
Near Real-Time Mosaics
Near Real-Time Precision Registration

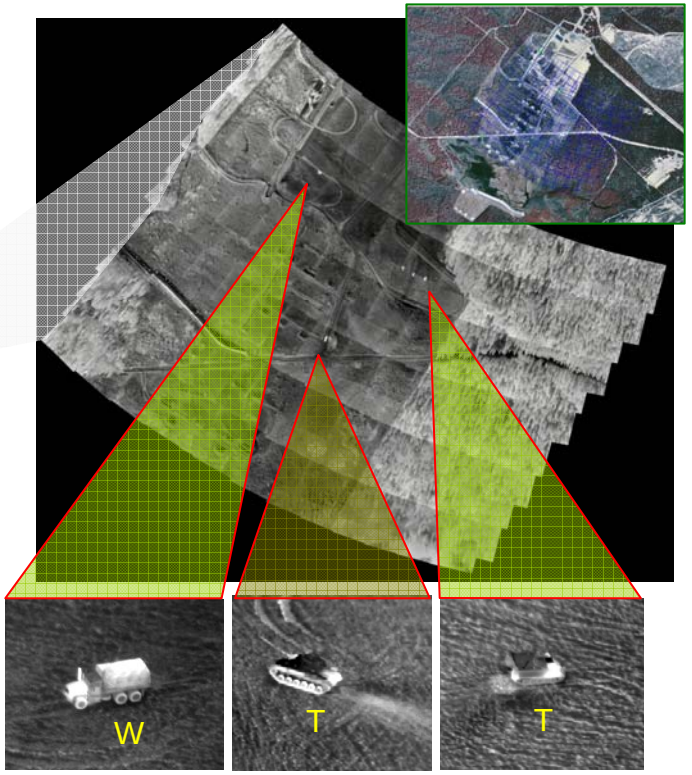




Day/Night Mine Detection

Laser Designator





Aided Target Recognition

An Affordable, Lightweight, High Performance Multi-Mission Payload

Aided Target Recognition with Step Stare Search

Manned Testbed Aircraft

AVS / UAV Payloads

ALERT / M-SUITE

HSI Program

Pilotage